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UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY

FOREST INSECT INVESTIGATIONS

REPORT

OF

EXPERIMENTAL INSECT CONTROL WORK

DRY PARK

KAIBAB NATIONAL FOREST.

October 1924.

By
F.P.Keen,
Associate Entomologist
U.S. Department of Agriculture

P.O. Box 3010,
Stanford University, Calif.
April 6, 1926

GOVERNMENT PRINTING OFFICE

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Copies to
District Forester, Ogden
The Forester
Forest Supervisor, Kaibab
Dr. Craighead,
Dr. Blackman

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DRY PARK EXPERIMENTAL WORK

During the spring of 1924 Messrs. Edmonston and Hofer, under the direction of Dr. Craighead, carried out some experiments on the Kaibab National Forest, to determine if some simplier and more effective methods of controlling the Black Hills beetle could be devised. Certain of these methods proved to be quite effective in killing the beetles and it was then suggested by Dr. Craighead and Mr. Miller that these experiments be conducted on a larger scale to determine their cost and general effectiveness when used in regular control work.

Upon approval by the Forester a camp of nine men was established at Dry Park on the Kaibab National Forest, on September 18th and 722 trees were treated by various methods until the camp closed on October 8th.

OBJECTS

The objects of the experiment were to determine:-

(1) the practical application of the various methods of control which gave the most promise of success.
(2) the relative costs of these methods.
(3) the relative effectiveness of these methods in killing the Black Hills beetle.

METHODS

The methods which were to be tested out and the number of trees treated under each method were as follows:-

Experiments A. Trees felled north and south, and not peeled.

1. Tops and limbs left on.
   117 trees treated on 320 acres.
2. Log laid on ground.
   144 trees treated on 160 acres.
3. Trimmed and brush spread.
   83 trees on 730 acres.
4. Trimmed and brush spread and log cut out.
   72 trees on 160 acres.

Experiments B. Trees felled and peeled.

1. All peeled, tops left on.
   72 trees treated on 160 acres.
2. All peeled, trimmed and brush spread.
   70 trees treated on 160 acres.
3. Half peeled, log turned one half turn, not trimmed.
   59 trees treated on 320 acres.
4. Half peeled, log turned one half turn, trimmed and brush spread.
   121 trees treated on 250 acres.

Experiments C. Trees cut and bark burned.

1. Top half peeled, bark burned, tops left on.
   None treated.
2. Top half peeled, bark burned, trimmed and brush spread.
   None treated.
3. No peeling, bottom half of log scorched, tops left on.
   34 trees treated on 40 acres.
4. No peeling, bottom half of log scorched, trimmed and brush burned.
   None treated.

Each experiment was carried out on a given block of timber, varying from 160 acres to 730 acres. The time of treating each tree was noted and the difference between the total treating time and the time which the crews spent in the field was charged to walking time.

Since the time spent in treating varies with the diameter of the trees, each method was plotted on a separate chart to show the time consumed in treating the various sized trees, and these charts were used to obtain the averages and costs of treating.

Thefollowing year on June 11th, Dr. Blackman, Mr. Mann, Mr. Morse and myself made a hurried examination of the area and took some notes of the condition of the trees. Later on July 10th in company with Dr. Craighead many of the logs were examined and notes made of their condition. On July 23rd to 26th, Dr. Blackman, Mr. Hofer, Mr. Henry and myself made a bark count analysis of a large series of trees and felled and made counts from twenty eight infested standing trees just south of the treated area. This was done to determine the number of beetles ready to emerge from the various trees and this determine the effectiveness of the methods.

These data with the conclusions which have been reached as to the efficiency of the methods is contained in this report.

SUMMARY OF THE EXPERIMENTS.

"A" Series of Experiments.

In this group of experiments the trees were felled for the most part north and south, and no peeling of bark was done. Some trees were trimmed others laid on the ground and in some cases the infested log was cut out. These gave a range of moisture conditions which indicated the most favorable and least favorable conditions for brood development.

Experiment A-1 Felling only.

This experiment was conducted on the east half of section 24 T 36 N, R 1 E, a block of 320 acres. One hundred and seventeen trees were felled north and south and nothing further was done to them. Two man crews were used. The time of treating is shown in Chart 1 for various diameters. For a 20" tree the treating time averaged 13 man minutes per tree.

Bark counts from 99 square feet of bark on 15 trees taken on August 4th, 1925, showed an average brood of 17.3 adults per square foot ready to emerge. In fact, the trees treated in this way had much better broods than normal standing trees. This was undoubtedly due to the higher moisture content of the bark, which the trees had gained by laying under the snow thruout the winter, and which produced much more favorable conditions for brood development than the standing trees which dried out very quickly in the spring.

A subsequent cruise of this area showed a 9.2% reinfestation following the emergence from these trees.

Experiment A-2 Trees Felled and logs laid on ground.

This experiment was carried out on the 160 acres of the N.W.$\frac{1}{4}$ of Section 24 T 36 N R. 1 E.

The idea was that the logs in coming in contact with the ground would absorb and hold more moisture during the winter than if left up where the air could circulate freely around them.

In general the trees were felled north and south, 144 trees being treated in this manner. In some cases the trees fell in close to the ground and nothing further had to be done. In other cases the trees had to be bucked into logs by one or more cuts in order to bring the logs down to the ground. In analyzing the results these trees were tallied separately from those which were not bucked.

A two-man crew was used. The time of treating the various diameter trees is shown in Chart 2. For a 20 inch tree the treating time averages 20 man minutes per tree.

Bark counts were made on July 26, 1925, on 23 trees and 207 square feet of bark. Nine trees in which the log was not cut out showed an average brood of 4.6 adults per square foot. The logs which had been cut and laid on the ground showed an average of 3.9 adults per square foot. Thus both of these methods developed better broods than were found in the untreated standing trees. The fall cruise of the area showed a 3.7% reinfestation which was practically the same amount of reinfestation as was found on adjacent untreated sections.

Experiment A-3 Trees Felled, Trimmed and Brush Spread.

This experiment was conducted on the east half of Section 23, the south half of Section 13 and the east half of Section 26. Altogether 83 trees were treated on 730 acres.

Trees were felled north and south, trimmed, and the brush spread. The spotting was done by the treating crew, a three man crew being used. Chart 3 gives the time of treating for various sized trees. A 20 inch tree required 25 man minutes to treat in this manner.

No further examination was made of these trees to determine the effect upon the beetles. But it is safe to assume that in general there was very little difference between the results of this method and experiment A-2, where the logs were trimmed but not cut in two.

Experiment A-4 Trees Felled Infested Log Cut Out, Trimmed, and Brush Spread.

This experiment was conducted on the southwest quarter of Section 24. Altogether 72 trees were felled north and south, the infested length cut out, the rest of the tree trimmed and the brush spread. The time of treating various sized trees is shown in Chart 4, the average time for a 20 inch tree being 26 man minutes.

On July 25th and 26th, these logs were examined for condition of the broods and bark counts were taken on 53 trees and in 594 square feet of bark. The bark on most of the trees showed a very characteristically wet condition which had been very unfavorable for brood development. Much of the bark was moldy or in a "sour sap" condition.

Trees treated in this way had an average brood of 29 adults per square foot which was the poorest brood development of any treated trees, and slightly poorer than normal untreated trees.

There was more Cerambycid work under the bark than in trees felled in experiment A-1, or in standing trees ; about the same amount of work as in experiments A2 but less Cerambycide work than in experiment B-3 where half of the log was peeled.

The check cruise made in October showed a 10.3% reinfestation on the area treated by this method. While this was more reinfestation than on the areas treated by other methods or on untreated areas, still this method promises some degree of success, and should be followed up for a few more seasons.

"B" Series of Experiments

The "B" series of experiments were all modifications of the peeling method, to determine the relative cost and effectiveness of these methods as compared with the other experimental methods. Some trees were peeled for the entire infested length, others were peeled for half the circumference and rolled. These two methods were varied by trimming and not trimming the tops.

Experiment B-1 Trees Felled, All Peeled, Tops left On.

This experiment was conducted on the southeast quarter of Section 25. 72 trees were treated on 160 acres. Two and three man crews were used. The time required to treat trees of various diameters by this method is shown in Chart 5. The time required for a 20 inch tree was 104 man minutes.

Peeling in the fall was found to be quite a bit more difficult than similar work in the spring, due to the less loosening of the bark by larval mines. Similar sized trees were peeled in spring work in 85 man minutes.

Examination of these trees during the following July showed that the work had been very thoroughly done and few beetles had escaped the treatment. Consequently, no bark counts were made.

Tree examinations, however, showed that this work had been 98% effective in destroying the broods.

No survey of the area was made to determine the percentage of reinfestation.

Experiment B-2 Trees all peeled, trimmed, and brush spread.

This experiment was similar to the above. The only difference was in the matter of trimming and spreading the brush which took some additional time.

It was carried out on the Northeast quarter of Section 25 70 trees were treated. The average time for treating a 20 inch tree was 115 man minutes (See Chart 6.)

Examination in July showed the same effective brood destruction as for B-1. No check survey was made to determine the amount of reinfestation.

Experiment B-3 Log Circumference half peeled, and log rolled. Trees not trimmed.

This method was employed in the treating of 59 trees on the 320 acres of the west half of section 25. The time required to treat various sized trees is shown in Chart 7. For a 20" tree, 70 man minutes was required.

It was expected that this method would prove very effective, that the unpeeled bark on the top of the log would dry out and the beetles would be killed by the sun. But examinations made during July of the following year showed that this bark had absorbed a great deal of moisture while covered by the winter snows, and very little of it dried out to the point of being destructive to the beetles. In fact, it furnished very good conditions for beetle development. An average of 4 adults to the square foot were found in the unpeeled portion of the logs which was a higher number than found in untreated standing trees.

Cerambycid work was found to be more plentiful under the bark than in any of the other methods but they were apparently not very destructive to the developing adults.

No check cruise was made of this area to determine the percentage of reinfestation.

Experiment B-4 Logs half peeled, turned, trimmed and brush spread.

This experiment was carried out on the timbered portion of Section 30. 121 trees were treated on 250 acres.

The time of treatment for various sized trees is shown in Chart 8. It required 80 man minutes to treat a 20 inch tree.

There was no difference in the brood development in this method from that of the previous method, in which an average of 4 adults per square foot were found in the unpeeled bark.

No check cruise was made of this area.

"C" Series of Experiments.

This series of experiments was planned to test out various methods of burning the infested bark either with partial peeling or without peeling, and in methods of brush disposal. The Forest Supervisor, however, objected to any experiments of this nature being made until after it had snowed and so they had to be abandoned.

After a snow storm in October two groups of trees were felled and an attempt made to burn them, but due to the wet conditions a satisfactory burn could not be secured.

These groups were examined the following July. While the tops had burned satisfactorily many butt logs had stuck out from the pile and had not been scorched. Even so a very good kill of beetles had been for the most part secured, with 97% of the broods destroyed.

The time required to burn these groups averaged 25 man minutes per tree, but not enough work was done to give an adequate cost basis for this method. No recruise of the area was made.

THE TREATING COSTS.

The charts give the best indication of the relative costs of the various methods. From these can be determined the mean time of treating different sized trees and is better than taking the averages since an equal number of trees of each diameter were not treated by each method.

Table 1 is an extract taken from the charts showing the mean treating time in man minutes for 10" 20" and 30" trees, and the average mean time of the different operations involved in the treating work. While these time data are only strictly applicable to these Dry Park experiments, it is very probably that the average time of the various operations would be applicable to any treating work in this type of timber. Even the work carried on at Klamath Falls shows a close agreement with the time of treatment on the Kaibab when the various variables are taken into account. It is also interesting to notice that the cost of treatment under B-2 was practically the same as for the large amount of treating work conducted during the spring of 1924.

THE COST OF SPOTTING.

The spotting work in the experimental camp was not extensive enough to give a wide range in conditions. With an intensity of 200 trees per section a three man spotting crew will spot 100 trees per day. With an eight hour day, this is 1440 man minutes for a three man crew or approximately 15 minutes per tree. At one cent per man minute the cost will be 15 cents per tree.

Where a crew spots and treats at the same time, the walking time for a 200 tree per section infestation was found to amount to 35 minutes per tree, and where they treat trees previously spotted by a spotting crew the walking time is reduced to 16 minutes per tree.

Thus to compare the cost of spotting by the two methods for this intensity of infestation we find the costs are as follows:

Spotting by spotting crew.

15 man minutes per tree for spotting crew plus 16 man minutes per tree for treating crew or a total of 31 man minutes or a total cost of 31 cents per tree.

Spotting by treating crew.

Time determined to be 35 minutes per tree or a cost of 35 cents per tree.

Thus for a 200 tree per section infestation, it is slightly cheaper to use a spotting crew. It is also more satisfactory in many other ways, and probably results in a higher percentage of the trees being located and treated.

However, as the intensity of the infestation increases, the point is soon reached, where it is cheaper to have the spotting done by the treaters. A three-man spotting crew can only mark at the maximum about 300 trees per day with a walking time of 5 minutes per tree, and a cost of about 5 cents per tree. As the intensity of infestation increases the walking time of the treating crews is reduced to the point where it doesn't take them any longer to spot the trees than it does the spotting crew. Data is not available at the present time to determine just what this point may be but it is safe to say that for infestations above 1000 trees per section it would be cheaper to have one man in each treating crew spot the trees and have the work checked up by the camp foreman or an inspector, than to use a spotting crew.

EFFECTIVENESS OF THE METHODS.

The effectiveness of the methods in killing the Black Hills beetle broods was determined by examination of the logs during July of the year following the treatment. In cases where infested bark still remained on the logs, bark counts were made and the number of beetles developing per square foot were counted. These counts are summarized in Table 2.

Besides the counts made on the treated logs, a series of 28 trees were felled during July and bark counts made to determine what had occurred in standing untreated infested trees, in order to secure a comparison of the effectiveness of the various methods with untreated material.

These trees showed an average of 5% of the bark riddled by woodpeckers in their search for grubs. The trees which had been felled in the fall treatment remained under the snow all winter and had practically no woodpecker work. This woodpecker work helps very materially in drying out the standing trees during the early summer, and as a result a high percentage of the broods had died.

The bark count averages from these trees showed 3.2 beetles per square foot. Averages from all standing trees on which bark counts were taken thruout the northern end of the mountain showed an average of 5.3 beetles per square foot. This in itself would account for a 60% reduction in infestation out of the 80% general reduction which the survey of 1925 showed, since it takes approximately 14 beetles per square foot to make a successful attack.

But since the normal trees turned out such poor broods, this made a very poor showing for the various treating methods, which in only one case caused any higher beetle mortality. What would have occurred if the standing trees had turned out normal healthy broods is problematical and the more favorable methods should be given another trial to determine this point.

In Table 3 is given a summary of the effect of the various methods in destroying the beetle broods. The column percentage of normal brood is based upon the normal brood development of standing untreated trees. Thus in every case, except where the infested log was cut out, the developing brood was greater than that in standing trees. For methods which depended upon the destruction of the bark by peeling or burning and where no specific bark counts were available, the brood was considered as normal or 100%.

Percentage of bark destroyed means percentage actually peeled or burned. The percentage of effective treatment therefore depended upon a combination of these two factors - the percentage of bark destroyed and the percentage of brood destroyed in the remaining bark. The average time for treating a 20" tree was used and from these figures was derived the last column showing the comparative cost of the various methods on the basis of securing a theoretical 100% kill of beetles.

This table indicates that the burning method was the cheapest; the peeling method next; the log-rolling method next; the half peeling and rolling next and the cutting out of the infested log the most expensive. Other methods produced better broods than in the normal tree and so cannot be considered of any value whatever. The logs treated under A-2 where the infested length was cut out also yielded better broods than the normal trees. This treatment was practically identical with A-4 so that it is doubtful if the kill secured under A-4 was really very much different from no treatment at all.

AMOUNT OF REINFESTATION

In October 1925 section 24, in which three of the "A" series experiments were conducted and section 31, in which the counts were taken on normal trees, were recruised to determine the amount of new infestation. The sections in which the "B" and "C" experiments were conducted were not recruised.

The results were as follows:

Method	Location	Beetles per sq. ft. Emerging from Trees	Percent of New Infestation.
Normal Untreated	Section 31	3.2	3.6 %
A-1 Trees felled	E½ Sec. 24	17.3	9.2 %
A-2 Log Laid on Ground	NW¼ Sec.24	4.2	3.7 %
A-4 Log Cut Out	SW¼ Sec.24	2.9	10.3%

The comparison of bark counts and new infestation on such small areas does not mean very much, since a slight shift in the infestation onto or off of the treated plots will give a large variation in the results.

In fact, it is doubtful if subsequent infestation can ever be used as an index of the success of a method except on large areas, and when all due allowance is made for the normal progress of the infestation. The best available criterion of success for small plots is whether or not the method has actually killed the beetles, and to what extent the predators and parasites have been saved.

CONCLUSIONS.

The conclusions to be drawn from the Dry Park experiments are as follows:

1. Moisture is a very important factor in the successful development of the Black Hills beetle. Very dry bark such as was found on standing trees is decidedly unfavorable. Very wet conditions produced in trees in which the infested length had been cut out was also unfavorable. Infested trees felled in the fall and left over winter under the snow with the branches and needles still on absorbed enough moisture to produce nearly optimum conditions for brood development.

2. All methods of treating trees by felling without peeling or burning failed to cause as great mortality to the broods as occurred in standing untreated trees, with the exception of the method in which the infested log was cut out. This method caused only a slightly higher mortality than occurred in the normal trees.

3. Burning was found to be the cheapest method when considering the efficiency of kill, with peeling only slightly more expensive.

4. For infestations of less than 200 trees per section, spotting with a spotting crew was found to be cheaper than using the treating crew for this purpose. For infestations above 1000 trees per section, it is probable that the spotting crew can be dispensed with.

5. The recruises of the treated plots gave results which were not comparable with the bark counts, and indicated that such a method in determining the success of a treating method was open to a high degree of error.

6. The method of cutting out the infested length, which gave the most promise of success as a biological method of control, should be tried again in other years when the normal standing trees are developing healthy broods. If a high percentage of beetles can be killed by this method it has an advantage over other methods in that the predators and parasites of the beetle are saved.

TABLE I

ADJUSTED TIME OF TREATMENT
FOR VARIOUS SIZED TREES

Method	10" man minutes	20" man minutes	30" man minutes
A 1. Fell only	4	13	29
A 2. Fell, lay log on ground	6	20	44
A 3. Fell, trim	7	25	57
A 4. Fell, trim, cut out log.	8	26	66
* Ditto (computed)	8	29	66
C 3. Fell, trim, burn bottom half of log, tops and limbs.	8	25	65
* Ditto (computed)	8	50	112
* Fell, trim, cut out log later return & roll.	11	41	99
B 3. Fell, half peel, roll	23	70	148
B 4. Fell, trim, half peel, roll	25	82	180
Fell, trim, half peel burn (Klamath Falls Project)	25	95	200
B 1. Fell, all peel	33	104	176
B 2. Fell, trim, all peel	33	115	200

Average Time of Different Operations/

	Man minutes	man minutes	man minutes
Felling	4	13	29
Trimming	2	12	28
Lay log on ground	2	7	15
Cut out log	2	4	9
Rolling	3	12	33
Peeling all log	28	90	145
Peeling half log	17	45	88
Burning (data inadequate.)			

TABLE II.

SUMMARY OF BARK COUNT DATA

DRY PARK EXPERIMENTS

Exp.	Method	Examined: Trees	Examined: Bark sq.ft.	DBH	Dia. Top	Inf. Length	Ring to last ½ inch.	Depth Sap Wood	Beetles Per Sq. Ft.: 10	20	30	40	50	60	70	Total	Ceram-bycid: work	Wood-pecker's work
A-1:	Felled - not Trimmed.	15	99	18.6	12.9	36.8	21.2	5.6	19.2	18.3	17.1	10.3	14.5			17.3	13%	0%
A-2:	Log laid on ground. (without cutting). Top trimmed.	9	78	17.5	10.0	40.7	19.9	5.7	2.5	1.5	5.2	9.1	9.4			4.6	25%	0%
A-2 (4):	Log laid on ground. (log cut out) Top Trimmed	14	129	19.0	11.5	36.0	18.3	5.4	3.2	4.2	2.7	4.9	6.0	11.0		3.9	23%	0%
A-4:	Log Cut Out Top trimmed	53	594	18.0	11.0	40.2	20.7	4.9	2.3	2.6	3.3	4.1	3.2	2.6	3.7	2.9	25%	0%
B-3:	Log peeled ½ & turned. Not trimmed	20	186	19.7	11.7	42.3	20.1	4.8	3.5	4.5	4.4	1.9	4.0	9.8	10.0	4.0	35%	0%
	Normal trees	28	337	20.6		34.4	22.1	5.2	2.3	3.1	4.1	4.7	2.6	1.6	3.5	3.2	20%	5%

1 Bark count only for unpeeled portion.

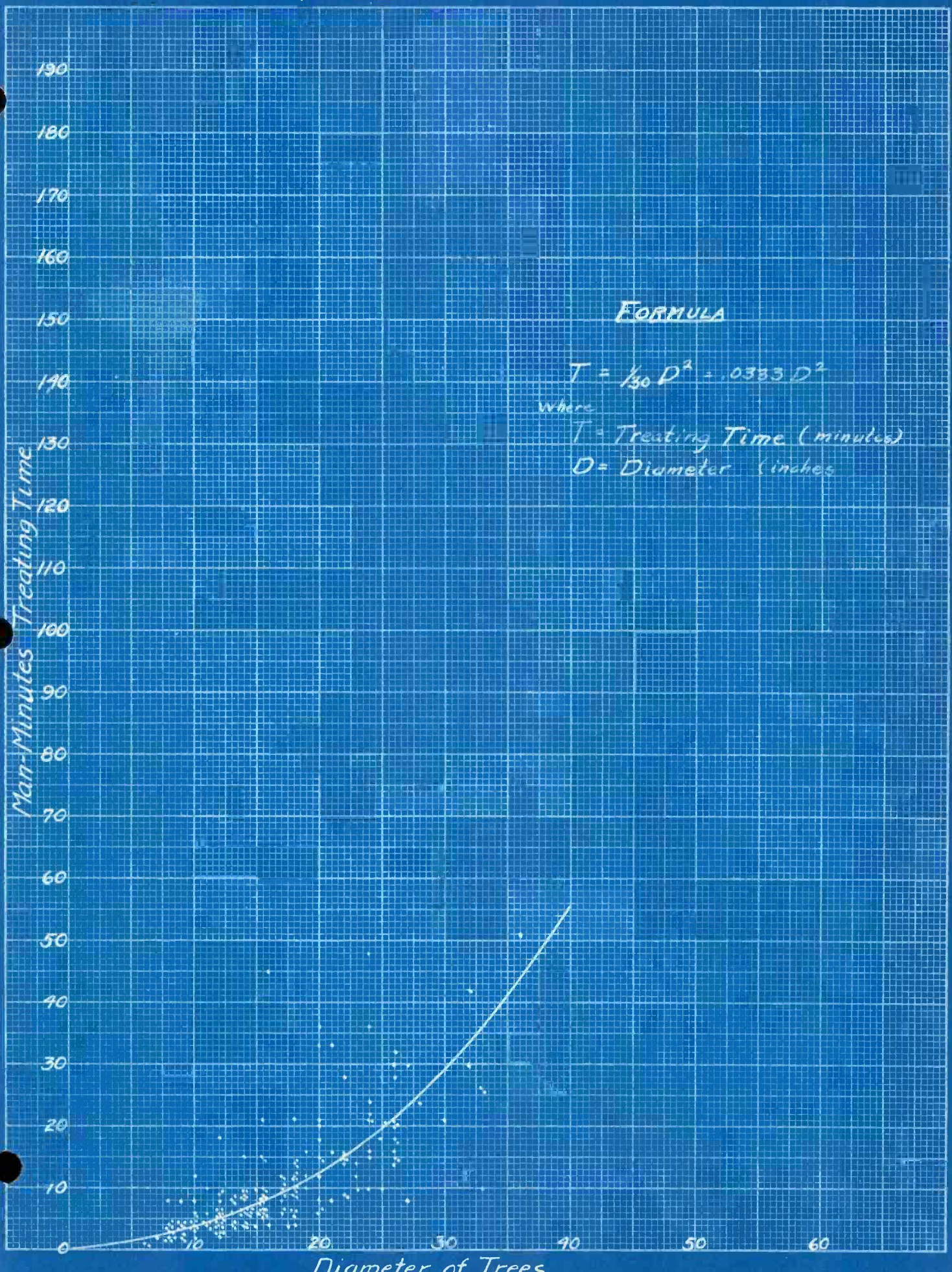
TABLE XI.

COMPARISON OF EFFECTIVENESS OF VARIOUS EXPERIMENTAL CONTROL METHODS.

Exp.	Method of Treatment	Average No Beetles Produced per sq. ft.	Persent of Normal brood	Percentage of Bark Destroyed	Percent Effective	Time per 20" tree	Cost per tree for 100% effectiveness
	Normal standing Trees	3.2	100%	0	0	0	0
A-1	Tree felled-not trimmed	17.3	540%	0	440%	13	No value
A-2	Log laid on ground (not cut out)	4.6	144%	0	44%	20	" "
A-2	Log laid on ground (cut out)	3.9	122%	0	22%	20	" "
A-3	Trees felled - trimmed		144%	0	44%	25	" "
A-4	Log cut Out	2.9	91%	0	9%	26	$2.89
B-1	Log Peeled- Not trimmed		100%	98%	98%	104	1.06
B-2	Log Peeled - Trimmed Brush spread		100%	98%	98%	115	1.17
B-3	Log Peeled ½ and turned - not trimmed	4.0	125%	45%	31%	70	2.26
B-4	Log Peeled ½ & turned- trimmed.		125%	45%	31%	82	2.64
C-3	Burned- not peeled- not trimmed*		125%	84%	80%	25	.31
	Peeled (Spring Work)		100%	97%	97%	100	1.03
	Burned (" ")		100%	99%	99%	84	.85
	Log Rolled(" ")		35%	0	65%	100	1.54

*Not sufficient number on which to base conclusions.

Experiment - A1 - Fell Only



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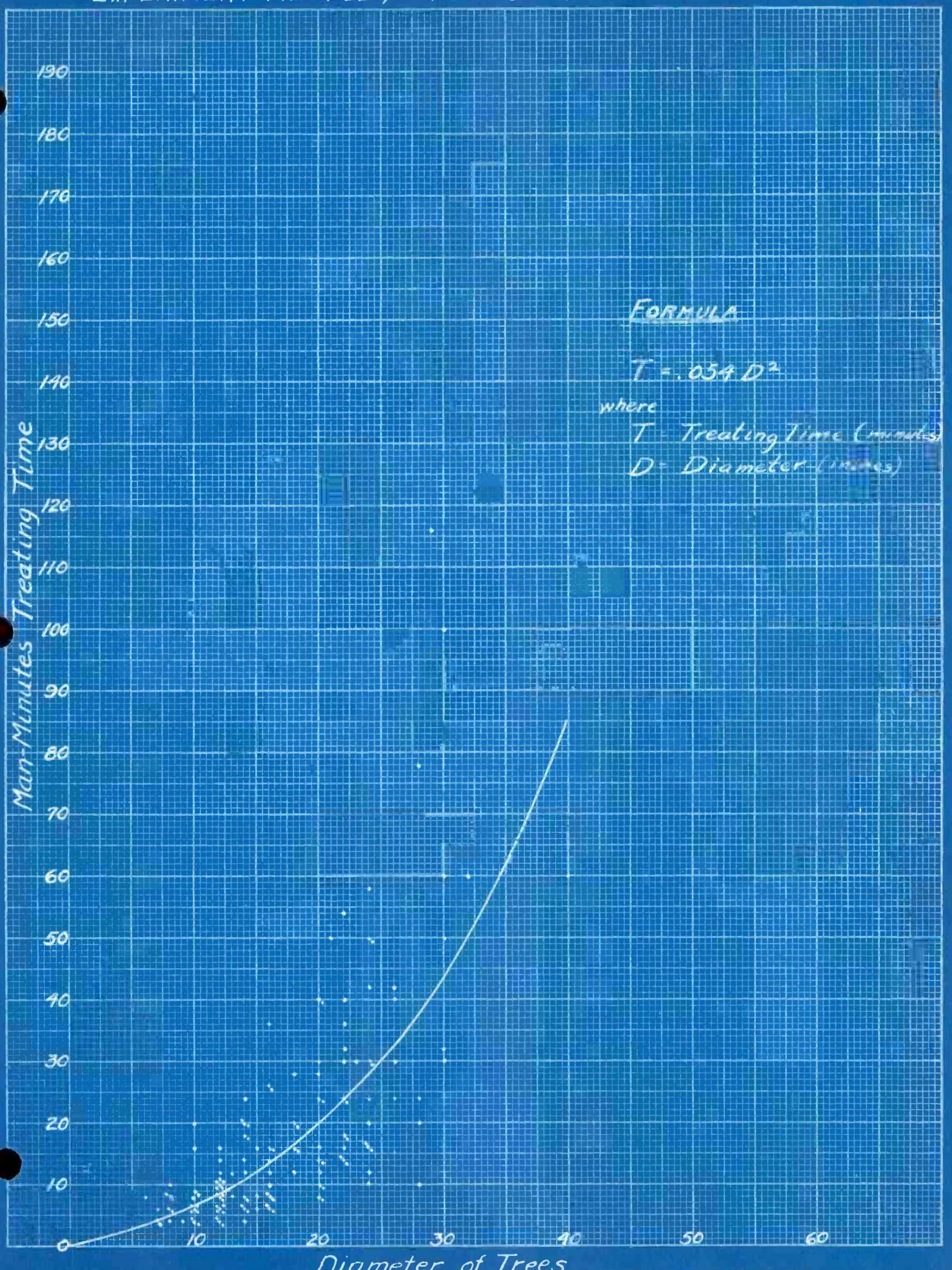
EXPERIMENT-A2- FELL, LAY LOG ON GROUND



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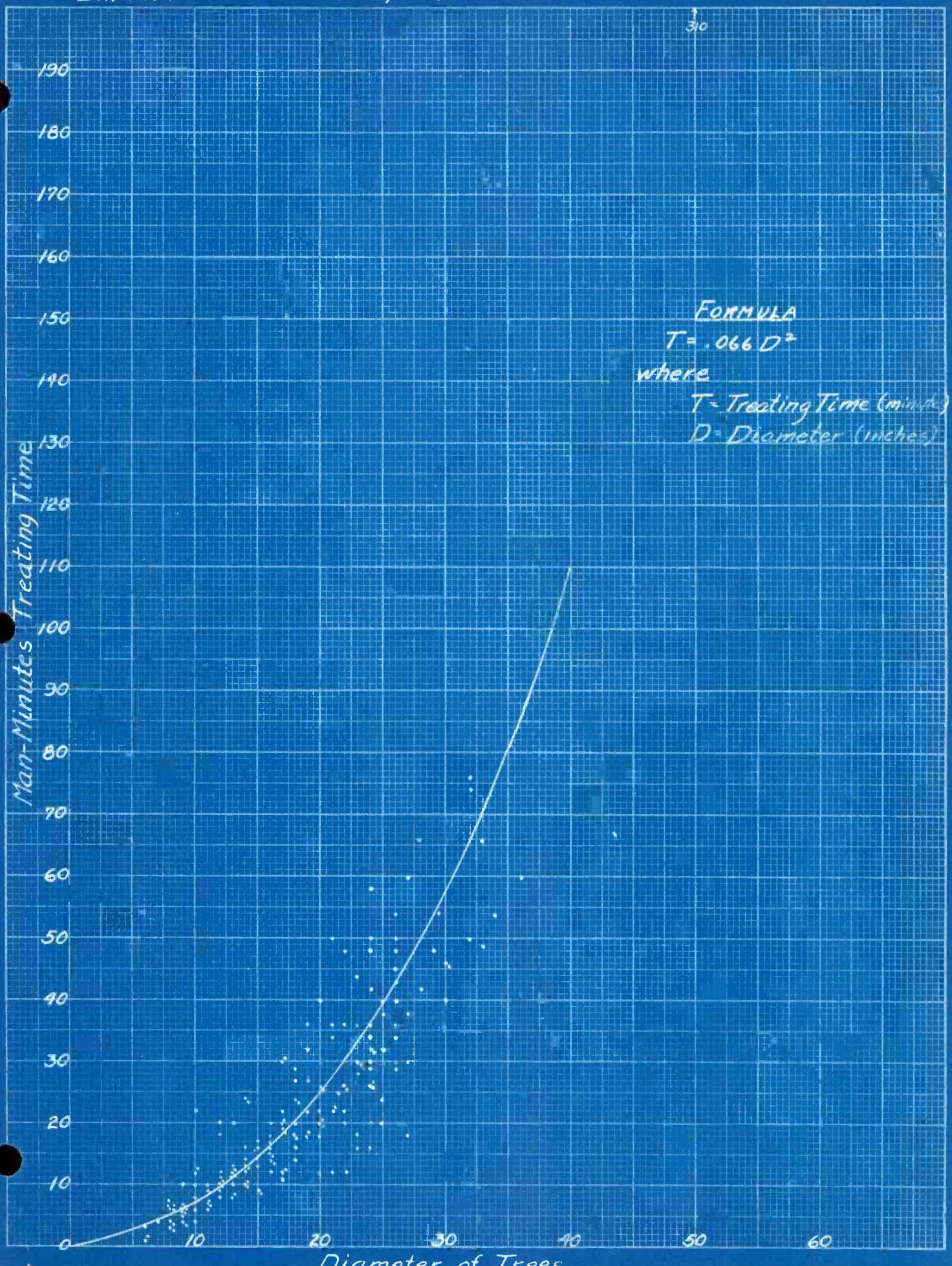
EXPERIMENT-A3 FELL, TRIM



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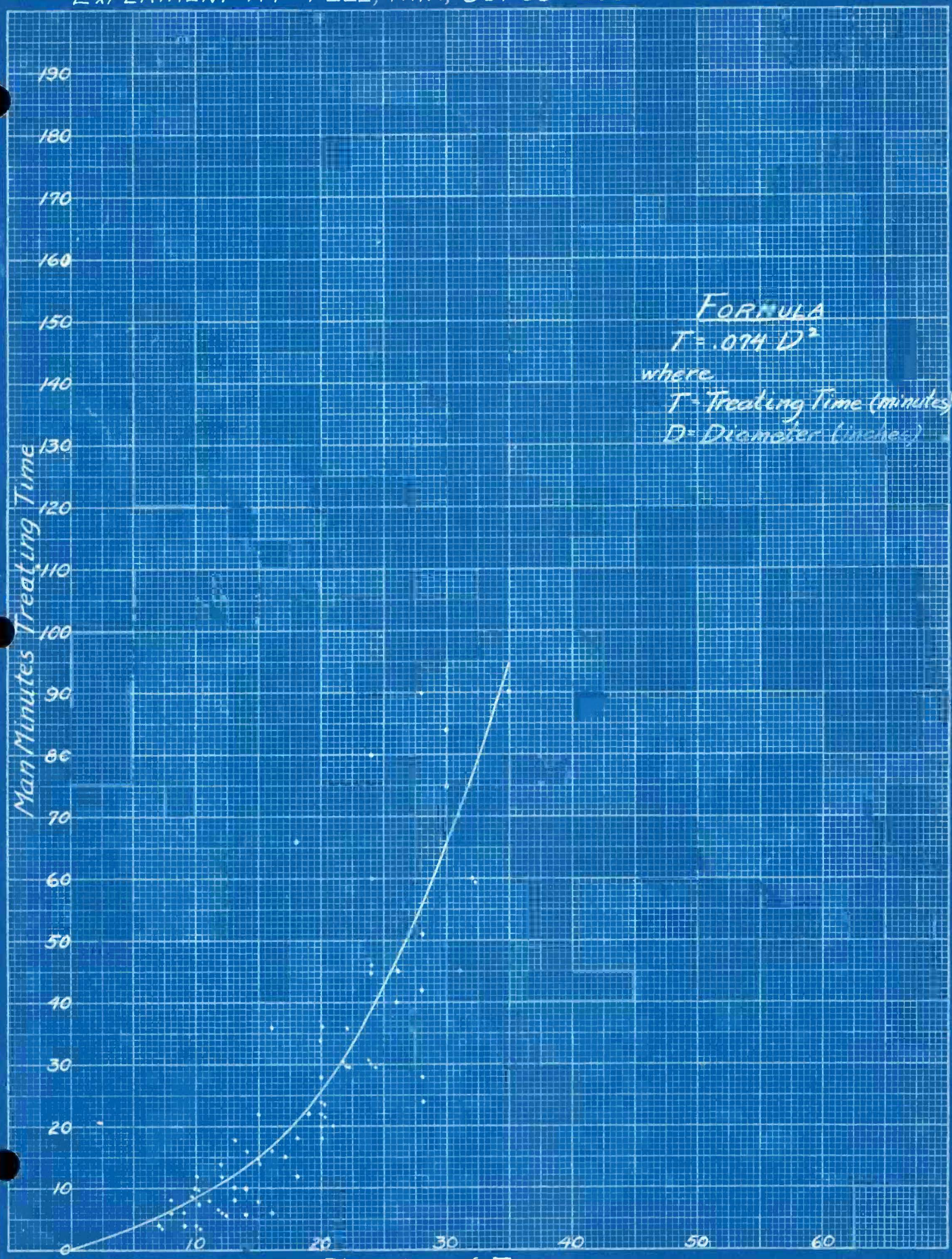
Experiment-A4- Fell, Trim, Cut Out Log



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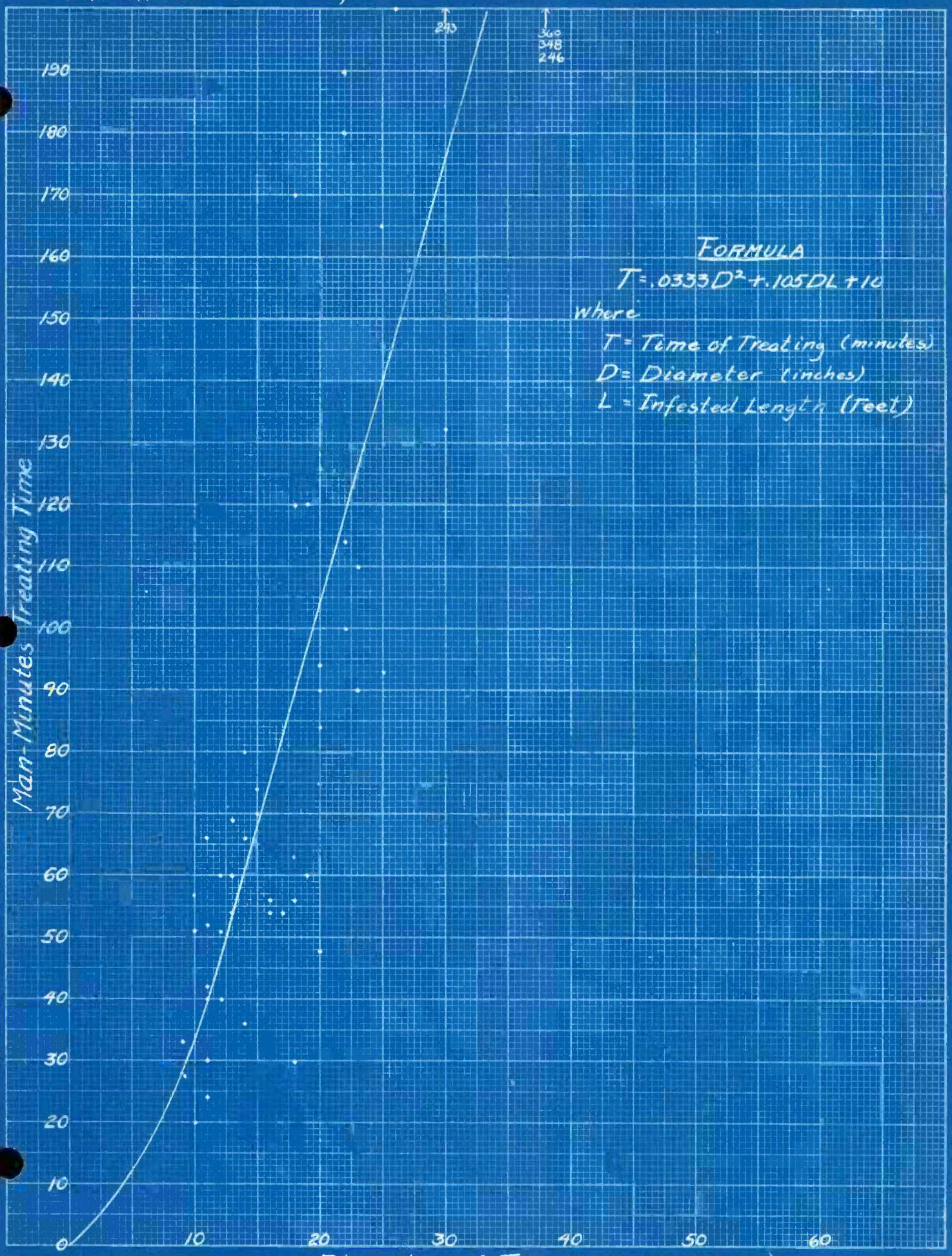
EXPERIMENT-B1-FELL, ALL-PEEL



FORMULA

$T = .0333D^2 + .105DL + 10$

Where

T = Time of Treating (minutes)

D = Diameter (inches)

L = Infested Length (Feet)

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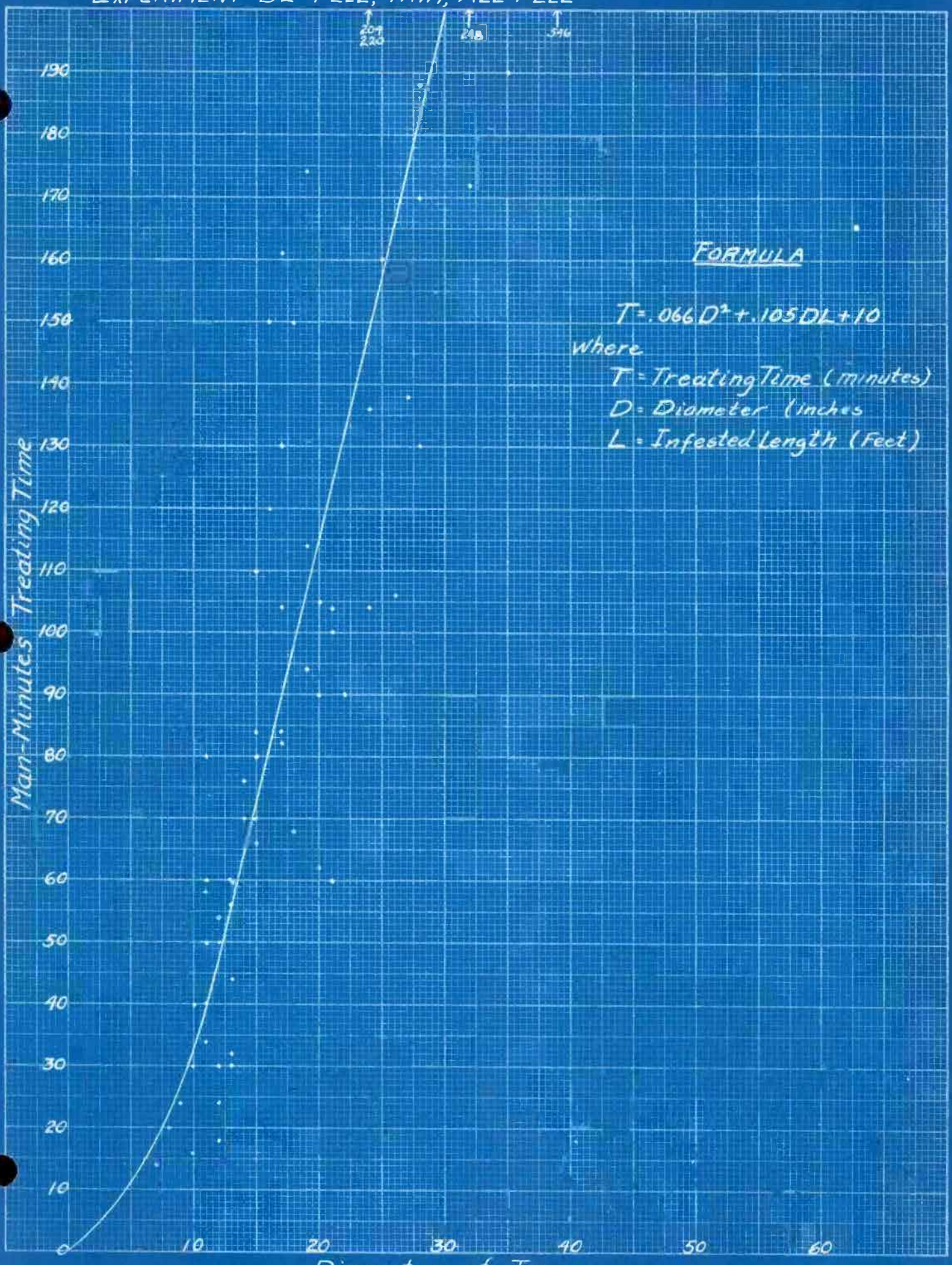
EXPERIMENT-B2- FELL, TRIM, ALL-PEEL



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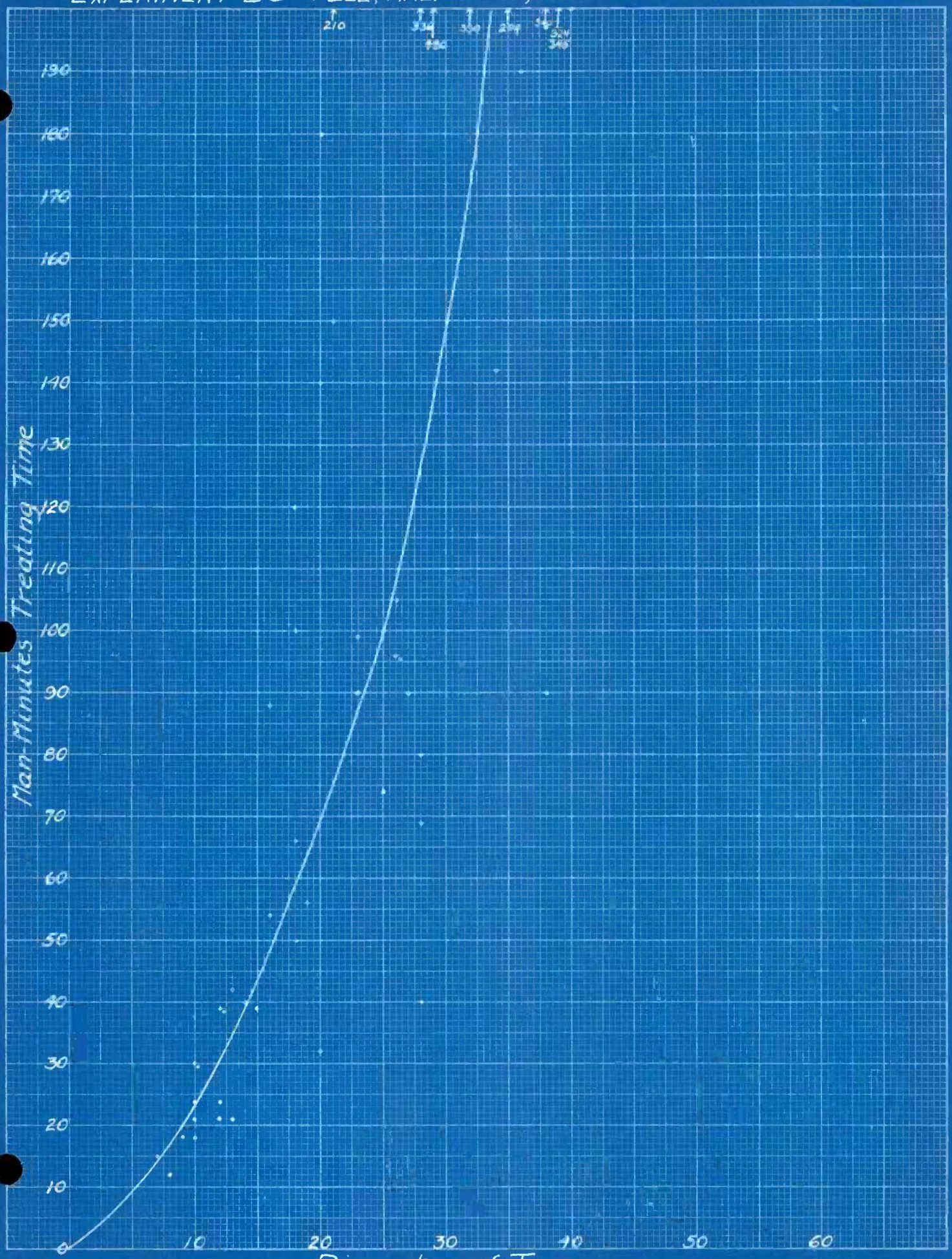
NO. 334 C.

Experiment-B3 - Fell, Half-Peel, Roll



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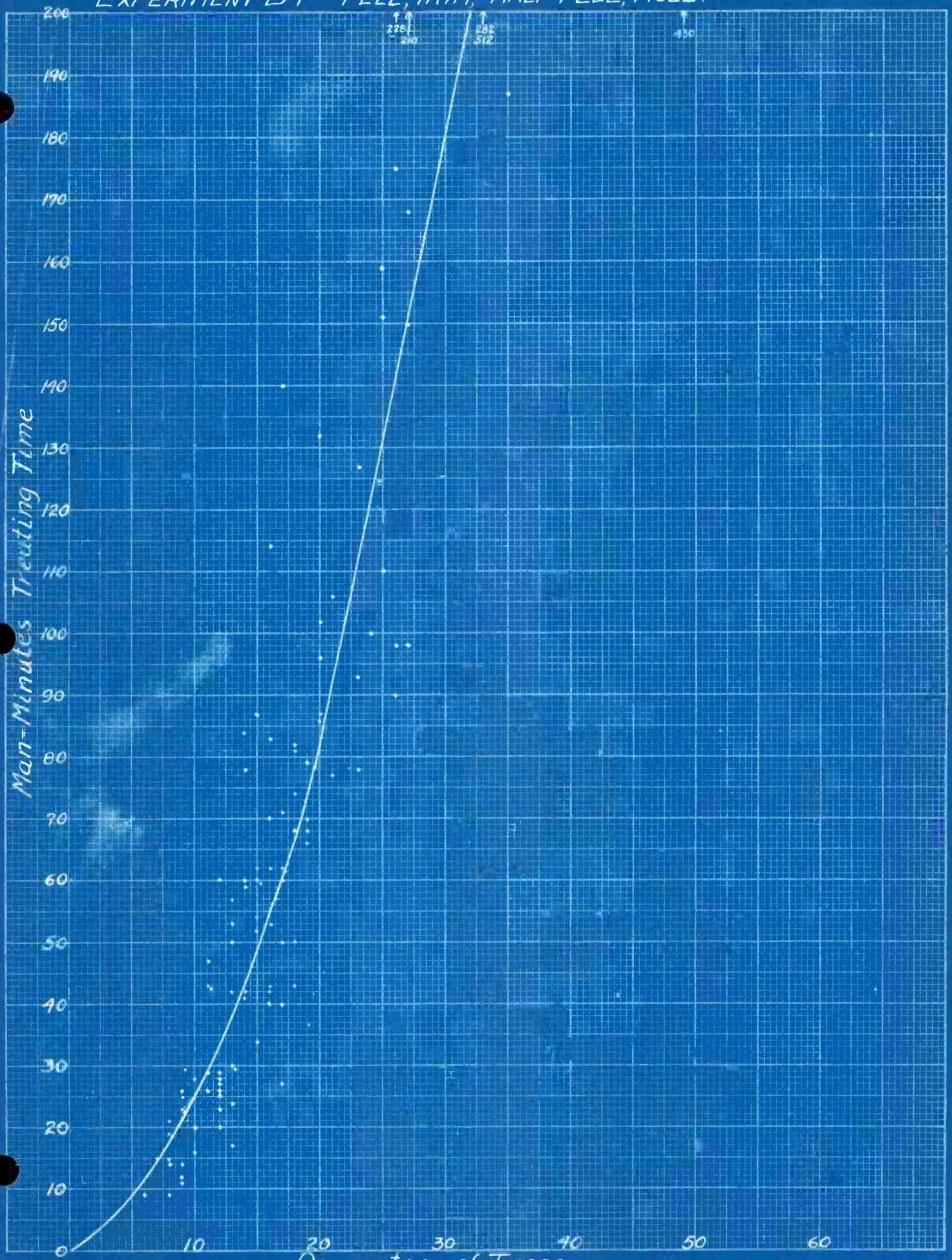
EXPERIMENT-B4 FELL, TRIM, HALF-PEEL, ROLL.
228
210
282
512
430
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Man-Minutes Treating Time
10
20
30
40
50
60
Diameter of Trees
KEUFFEL & ESSER CO., NEW YO
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